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Jc135 U.S. PTO 09/134147 08/14/98

TO: Assistant Commissioner for Patents
Box Patent Applications
Washington D.C. 20231

Jc605 U.S. PTO 08/14/98

Attorney Docket No.50169/110
(must include alphanumeric codes if no inventors named)

UTILITY PATENT APPLICATION TRANSMITTAL
(new nonprovisional applications under 37 CFR 1.53(b))

Transmitted herewith for filing is the patent application of:

INVENTOR: **Wallace T.-Y. TANG**

TITLE: **IN-SITU REAL-TIME MONITORING TECHNIQUE AND APPARATUS FOR DETECTION OF THIN FILMS DURING CHEMICAL/MECHANICAL POLISHING PLANARIZATION**

In connection with this application, the following are enclosed:

APPLICATION ELEMENTS:

XX Specification - 16 TOTAL PAGES

(preferred arrangement:)

-Descriptive Title of the Invention
-Cross Reference to Related Applications
-Statement Regard Fed sponsored R&D
-Reference to Microfiche Appendix
-Background of the Invention
-Brief Summary of the Invention
-Brief Description of the Drawings (if filed)
-Detailed Description
-Claims (7 pages)
-Abstract of the Disclosure (1 page)

XX Drawings - Total Sheets 6

XX Declaration and Power of Attorney and Associate Power of Attorney - Total Sheets 2

___ Newly executed (original or copy)

XX Copy from a prior application (37 CFR 1.63(d))
(relates to continuation/divisional boxes completed) - NOTE: Box below

___ DELETION OF INVENTOR(S) - Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).

XX Incorporation By Reference (useable if copy of prior application Declaration being submitted)

The entire disclosure of the prior application Serial No. 08/401,229, from which a COPY of the oath or declaration is supplied as noted above, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

___ Microfiche Computer Program (Appendix)

___ Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)

___ Computer Readable Copy
___ Paper Copy (identical to computer copy)
___ Statement verifying identify of above copies

ACCOMPANYING APPLICATION PARTS

___ Assignment Papers (cover sheet & document(s))
___ 37 CFR 3.73(b) Statement (when there is an assignee)
___ English Translation Document (if applicable)
XX Information Disclosure Statement (IDS) with PTO-1449. ___ Copies of IDS Citations

____ Preliminary Amendment
XX Return Receipt Postcard (MPEP 503)
XX Small Entity Statement(s)
XX Statement file in prior application, status still proper and desired.
____ Certified Copy of Priority Document(s) with Claim of Priority (if foreign priority is claimed).
XX OTHER: Preliminary Remarks

If a **CONTINUING APPLICATION**, **check appropriate box and supply the requisite information:**

XX Continuation of prior application Serial No. 08/401,229, filed March 9, 1995, which is in turn a divisional of Serial No. 07/996,817, filed December 28, 1992.

CORRESPONDENCE ADDRESS:

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FEE CALCULATIONS: (Small entity fees indicated in parentheses.)

(1) For	(2) Number Filed	(3) Number Extra	(4) Rate	(5) Basic Fee $790 ($395)
Total Claims	31 - 20 =	11	x $22 (x $11)	121.00
Independent Claims	6 - 3 =	1	x $82 (x $41)	41.00
Multiple Dependent Claims			$270 ($135)	
Assignment Recording Fee per property			$40	
Surcharge Under 37 C.F.R. 1.16(e)			$130 ($65)	
			TOTAL FEE:	$557.00

METHOD OF PAYMENT:

A check in the amount of the above TOTAL FEE is attached. If payment by check is NOT enclosed, it is requested that the Patent and Trademark Office advise the undersigned of the period of time within which to file the TOTAL FEE. If payment enclosed, this amount is believed to be correct; however, the Commissioner is hereby authorized to charge any deficiency or credit any overpayment to Deposit Account No. 19-0741.

Respectfully submitted,

Stephen B. Maebius

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Date: August 14, 1998
Docket No.: 50169/110

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Attorney Docket No. 50169/110

In re patent application of

Wallace T.Y. TANG

Con. of Ser. No. 08/401,229

Filed: August 14, 1998

Group Art Unit: 2874

Examiner: J. Lee

For: IN-SITU REAL-TIME MONITORING TECHNIQUE AND APPARATUS FOR DETECTION OF THIN FILMS DURING CHEMICAL/MECHANICAL POLISHING PLANARIZATION

PRELIMINARY REMARKS

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

During prosecution of the parent application (Serial No. 08/401,229), the Examiner concluded that certain claims needed to be placed into an interference with U.S. Patent No. 5,433,651 to Lustig et al. (Lustig '651), while other claims were separately patentable to the applicant without an interference. Accordingly, the Examiner agreed to permit applicant to file the present continuation application in order to separate the interfering claims from the claims that could be passed to issue without an interference. The interfering claims have been filed as part of the present application and will be canceled from the parent application in an amendment that will be filed shortly in the parent application. The claims remaining in the parent application will then be passed to issue without an interference, since they were found to be separately patentable relative to the Lustig '651 claims.

The correspondence between the instantly filed claims and the parent claims is as follows:

Continuation of Serial No. 08/401,229

Parent claim #	Present claim #
48-52	1-5
61-73	6-18
75	19
79-90	20-31

The present claims were transferred verbatim from the corresponding claims in the parent application (only the numbering is different).

Applicant respectfully requests that an interference be declared between the present claims and the claims of Lustig '651.

Respectfully submitted,

August 14, 1998
Date

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Atty. Doc. No. 50169/110

Inventor: Wallace T.Y. Tang

IN-SITU REAL-TIME MONITORING TECHNIQUE AND APPARATUS FOR DETECTION OF THIN FILMS DURING CHEMICAL/MECHANICAL POLISHING PLANARIZATION

This application is a continuation of co-pending U.S. Serial No. 08/401,229 filed on March 9, 1995, which is a divisional of U.S. Serial No. 07/996,817 filed on December 28, 1992.

FIELD OF THE INVENTION

The present invention is directed to a technique and apparatus for the optical monitoring and measurement of a surface undergoing rotation, particularly for in situ, real-time monitoring of any thin film undergoing rotation and simultaneous dimensional changes. It is particularly useful in the field of wafer planarization for producing wafers of extreme flatness and uniformity that are desirable in the production of semiconductor and integrated circuits.

BACKGROUND OF THE INVENTION

As microelectronic device dimensions continue to shrink, patterning problems increasingly hinder integrated circuit and semiconductor device fabrication. Semiconductor device fabrication often requires extremely planar surfaces and thin films of precise thicknesses. The surfaces requiring planarization and thickness control in semiconductor devices include areas or layers of dielectric material (such as SiO_2) on the surface of semiconducting materials and other device pattern

layers. The insulating dielectric layers and other device layers need to be extremely planar because irregularities and rough topography lead to fabrication problems, including Depth of Focus budget (hereafter DOF) problems. Since an irregularity in the surface can cause part of the surface to be out of focus at a particular distance between the optical system and the wafer, errors in pattern formations can occur. Also, the thickness of layers needs to be precisely controlled because variations in thickness may affect the electrical properties of the layers and adjacent device patterns particularly in the interconnections between the different layers of microelectronic devices.

The precise control of layer thickness is also crucial in semiconductor device fabrication. In VLSI technology, certain layers of multi-layer devices are generally electrically interconnected. These layers are also typically insulated from various levels by thin layers of insulating material such as SiO_2. In order to interconnect the device layers, contact holes are often formed in the insulating layers to provide electrical access therebetween. If the insulating layer is too thick, the layers may not connect, if the layer is too thin, the hole formation process may damage the underlying device layer.

Due to the various inadequacies of other planarization methods (such as spin-on-glass and etchback), Chemical/Mechanical Polishing (hereafter CMP) planarization machines and other lapping machines have been developed and employed to provide planar surfaces for semiconductor device fabrication. Generally, CMP is

a technique of planarizing wafers through the use of a polishing pad attached to a rotating table. The wafer is held by a chuck above a polishing pad which rotates on a spindle. The wafer is pressed downward against the polishing pad. The nap of the rotating pad removes bits of the film layer, thereby planarizing the surface. A solution of pH controlled fluid and colloidal silica particles called slurry flows between the pad and the wafer to remove material from the polishing area and to enhance the planarization of the wafer surface.

A typical method of determining the endpoint of CMP and lapping machines is to measure the amount of time needed to planarize standard wafer(s), and then to process the remaining wafers for a similar amount of time. In practice, this process is very inefficient because it is very difficult to determine the precise rate of film removal, as polishing conditions and the polishing pad change from wafer to wafer over time. As a result, it is often necessary to inspect the wafers individually after planarization, which is time-consuming and expensive. Thus, the CMP process could be significantly improved by introducing an _in situ_, real-time measurement and control system.

The ability to monitor and control the CMP process has been directly and indirectly addressed by several techniques. One method is based on measuring capacitance (U.S. Patent No. 5,081,421). The theory behind this method is that the electrical capacitance of the wafer changes as the wafer surface is planarized. The two primary drawbacks of the method are its

limited accuracy and its pattern dependency. Its accuracy can be compromised by the patterns of underlying layers which may also affect the capacitance of the entire system.

One direct method has been proposed which uses laser light to make interferometric readings on the polished side (front side) of a section of the wafer which overhangs the polishing pad (U.S. Patent No. 5,081,796). The disadvantages of this system are that it requires substantial modification of the conventional CMP process since part of the wafer must overhang the edge of the polishing pad, leading to polishing uniformity problems, and also, the monitored spot on the rotating wafer must be coordinated with the apparatus underneath the wafer overhang.

An indirect method of monitoring CMP has been developed which senses the change in friction between the wafer and the polishing surface (U.S. Patent No. 5,036,015). The change in friction may be produced when, for instance, an oxide coating of the wafer is removed and a harder material is contacted by the polishing pad. The accuracy of the method suffers from variations in changing pad conditions. In addition, use of the method may be limited by the need to sense the friction generated by different materials.

Another indirect method of monitoring CMP has been developed utilizing the conductivity of the slurry during polishing (U.S. No. Patent 4,793,895). When metal layers are exposed during the CMP process, the electrical resistivity of the slurry and wafer changes due to the exposed metal on the wafer surface. The obvious drawback of this method is that it requires having exposed

metal surfaces for monitoring. This is not possible for most types of polishing situations.

Another indirect method of monitoring CMP has been developed utilizing the waste slurry off the pad during planarization (U.S. Patent No. 4,879,258). Certain materials are imbedded in the dielectric layer and monitored as they are planarized and fall off the polishing pad. The obvious drawbacks to this method include the time delay between planarization and when the slurry reaches the edge of the pad (estimated to be approximately 30 seconds) and also the low levels of sensitivity and signal noise introduced by the materials left over from the previous wafers. This method is not an active, real-time method.

These and other endpoint detection techniques do not offer effective and accurate control of the CMP process in an in situ, real-time manner. These schemes either compromise the accuracy of the endpoint detection and/or require significant alterations of the CMP process.

BRIEF DESCRIPTION OF THE FIGURES

Fig. 1 is a side view of a representative semiconductor device with a device pattern on a substrate of semiconductive material and a thick, unplanarized dielectric layer over the pattern and substrate.

Fig. 2 illustrates the semiconductor device of Fig. 1 after the dielectric layer has undergone CMP planarization.

Fig. 3 is a side view of a rotating coupler fitted with

fiber-optic cable.

Fig. 4 is a side view representation of the fiber-optic embodiment of the present invention integrated with a CMP assembly. The fiber-optic apparatus is pictured in both a front side and a back side approach.

Fig. 5 shows another embodiment of the present invention utilizing a light source which transmits light in the direction of the wafer, where it is reflected off the wafer's surface and the reflection is monitored by a photodetector which converts the light signal to an electrical signal. The electrical signal can be relayed to an analyzer after passing through an electrical slip ring.

Fig. 6 illustrates a wafer-holding chuck shown in Fig. 4, wherein air has been pumped into a cavity above the wafer to compensate for loss of pressure against the back of the wafer where holes are located.

SUMMARY OF THE INVENTION

An object of the present invention is to avoid the above-mentioned problems by allowing for the monitoring of a region of a film on a substrate undergoing thickness changes, thus enabling endpoint detection in an in situ, real-time manner. In addition, if the monitored region is sufficiently small, a spot on the wafer can be dedicated for endpoint purposes. The dedicated endpoint spot can remove signal problems associated with the layer's topology, patterns, and multiple film layers.

The present invention thus provides an apparatus and method for the optical illumination and monitoring of a section on a thin film layer undergoing dimensional changes. Light from a light source is transmitted to a monitoring area on the layer, preferably through the back side of the substrate, and relayed back to an analyzer which evaluates changes in thickness of the substrate based on interferometric, spectrophotometric, and/or absorption changes. In a preferred embodiment, the light signal is advantageously measured from the back side of the substrate, which facilitates implementation since the monitored region of the wafer and the monitoring apparatus do not need to be timed and coordinated during the process.

DETAILED DESCRIPTION OF THE INVENTION

In one embodiment, the present invention is a method of monitoring the thickness change of a film on a substrate comprising illuminating a section of the film through the back side (the side which is not being processed) of the substrate, measuring a light signal returning from the illuminated section, and determining change in thickness of the film on a substrate based on the measured light signal. Thickness change can be determined by an analyzer, which analyzes interferometric, spectrophotometric, absorption, and/or other optical changes in the measured light signal. Optionally, if the substrate is undergoing rotation, the method further comprises the step of relaying the light signal to a rotating coupler which links the

signal to an analyzer.

Another embodiment of the present invention is a method of monitoring the change in thickness of a film on a substrate comprising illuminating a section of the film from the front side (i.e., the side being polished) of the substrate, measuring a light signal returning from the illuminated section, and relaying the light signal to a rotating coupler which connects to an analyzer, and monitoring thickness change with the analyzer, which analyzes interferometric, spectrophotometric, absorption, and/or other optical changes in the measured light signal.

Another embodiment of the present invention is an apparatus for monitoring thickness change in a film on a substrate comprising a light source which illuminates a section of the film from either the front side or back side of the substrate to generate a light signal, means for detecting the light signal, means for analyzing the light signal, a rotating coupler for relaying the light signal from the illuminated section to the means for analyzing the light signal, and optionally one or more focusing lenses.

Preferably, the apparatus comprises

(i) a bifurcated fiber-optic cable having a common leg and two bifurcated legs,

(ii) a rotating fiber-optic cable with two ends,

(iii) a light source,

(iv) means for analyzing a light signal, and

(v) a rotating coupler having a stationary end and a

rotating end,

wherein the first bifurcated leg of the bifurcated fiber-optic cable is connected to the light source, the second bifurcated leg is connected to the means for analyzing a light signal, and the common leg is connected to the stationary end of the rotating coupler, and wherein one end of the rotating fiber-optic cable is connected to the rotating end of the rotating coupler and the other end is held in close proximity to the film on a substrate undergoing processing.

"Close proximity" includes any distance between the end of the rotating fiber-optic cable and the film on the substrate that is close enough to permit effective illumination of the monitored area of the film and effective reception of the returning light signal. A preferred distance is less than or equal to about 1 cm.

The rotating fiber-optic cable serves both to transmit light from the light source to the illuminated section and to transmit the returning light signal on its way back from the illuminated section. Light from the light source travels down the first bifurcated leg of the bifurcated fiber-optic cable and passes through the rotating coupler down the rotating fiber-optic cable to illuminate the film on a substrate. The returning light signal is relayed by the second bifurcated leg of the bifurcated fiber-optic cable to the analyzer. In addition, more than one section of the film on a substrate can be monitored at a time by using multiple legs of rotating fiber-optic cables which pass through one or more rotating couplers.

Preferably, the fiber-optic cable comprises multiple optic fibers bundled together. However, the fiber-optic cable may comprise a single fiber. Alternatively, it may be a combination of bundled fiber-optic cable and single fiber fiber-optic cable. Alternatively, it may be multiple fiber-optic cables bundled together.

The term "substrate" includes any insulating, conductive, and semiconductive materials known in the art. Preferred substrates are wafers such as silicon wafers, gallium-arsenide wafers, and silicon on insulator (SOI) wafers.

The term "film on a substrate" includes various dielectric layers known in the art, such as SiO_2, metal layers such as tungsten and aluminum, and various other films such as silicon films found on the substrate as defined above. The films also include resist layers.

The film undergoing thickness change, for example, may be a film on a substrate in a chemical mechanical polishing (CMP) process, a chemical vapor deposition process, a resist development process, a post-exposure bake, a spin coating process, or a plasma etching process. In the CMP embodiment, the film is located at the interface of the substrate and the polishing pad.

The term "light source" includes any source of light capable of illuminating a film on a substrate in the range of about 200 to about 11,000 nanometers in wavelength. If the light signal is measured from the back side of the substrate, the wavelength is preferably between about 1,000 and about 11,000 nanometers. A

preferred back side wavelength is 1,300 nanometers. If the light signal is measured from the front side, then the wavelength is preferably between about 200 and about 11,000 nanometers. A preferred front side wavelength is 632.8 nanometers. Preferably, the section of the film on the substrate is continuously illuminated by the light source, although illumination can be at timed intervals.

Suitable means for analyzing the light signal, or "analyzers", include photodetectors, interferometers, spectrophotometers and other devices known in the art for measuring interferometric, spectrophotometric, absorption, and/or other optical changes.

Suitable rotating couplers include any couplers known in the art for coupling a rotating member to a non-rotating member provided that light is permitted to pass between the ends of the two members. Such, couplers are disclosed, for example, in U.S. Patent Nos. 4,398,791 and 4,436,367. Preferably, the means for coupling the rotating fiber-optic cable to the bifurcated fiber-optic cable which is not rotating comprises a rotating member which attaches to one end of the rotating fiber-optic cable. The rotating member is fitted into a stationary member of the rotating coupler which is attached to the common leg of the bifurcated fiber-optic cable. The coupler is designed such that the end of the rotating fiber-optic cable is held in close proximity, preferably less than 1 cm, to the common leg of the bifurcated fiber-optic cable, thereby permitting light to pass between the

two ends. Optionally, the cable ends can be fitted with focusing lenses to enhance signal transmission.

The rotating coupler can be replaced with other types of couplers, including off-axis fiber-optic couplers, electrical slip rings, or a combination of the aforementioned couplers, or with other means of signal rotation decoupling.

Typical CMP machines in which the methods and apparatus of the present invention can be used are those produced by R. Howard Strasbaugh, Inc. in San Luis Obispo, California; Westech Systems, Inc. in Phoenix, Arizona; and Cybeq Systems in Menlo Park, California.

Figs. 1 and 2 illustrate CMP planarization of a semiconductor device wafer. In Fig. 1 is shown a representative semiconductor device, which includes a dielectric layer such as SiO_2, 1, deposited on the surface of a device pattern, 2, formed on a silicon wafer substrate, 3. The dielectric layer may be formed in a manner such as chemical vapor deposition (CVD) of oxide, spin-on-glass, or by other means. Fig. 2 shows the wafer of Fig. 1, but with the dielectric layer, 1, planarized to a preselected thickness after CMP. The device pattern, 2, and the wafer substrate, 3, are relatively unchanged in this process.

Fig. 3 is a side view representation of a preferred embodiment of the optical rotating coupler apparatus. Fig. 3 shows a bifurcated fiber-optic cable, 4, one bifurcated leg of which connects to a light source, 7, and another bifurcated leg of which connects to a photodetector, 8, which in turn is connected

to signal conditioning electronics and a computer processing and control system (not shown). The common leg of the bifurcated fiber-optic cable, 4, connects to an optical rotating coupler, 5. A rotating fiber-optic cable, 6, extends from the rotating coupler to the area of the wafer substrate to be monitored. The fiber-optic cables, 4 and 6, may be either single fiber or bundled fiber types. Also, it is possible to use several fiber-optic cables or fibers instead of one cable or fiber. Also, it is possible to make a hybrid single fiber and bundled fiber cable embodiment, e.g., cable 4 is single fiber and cable 6 is bundled cable. Focusing lenses are not necessary at the monitoring end of cable 6 if the cable is fixed securely and closely enough to the monitoring area of the wafer substrate. Preferably, the distance between the end of cable 6 and the wafer substrate is less than 1 cm.

Fig. 4 is a side view representation of a typical CMP planarizer or lapping machine adapted with the apparatus shown in Fig. 3. The apparatus may be set up in the planarizer from a back side approach with 4, 5, and 6, or from a front side approach with 411 51, and 61. only one of the approaches, either back side or front side, is needed at any one time for effective monitoring. In Fig. 4, the wafer holding-chuck and spindle, 12, is shown integrated with a rotating coupler, 5, for the back side approach. The bifurcated fiber-optic cable, 4, is fed into the spindle, 12, and connected to the stationary portion of the rotating coupler, 5, as shown in Fig. 3. The rotating fiber-optic cable, 6, is fed

down the spindle to the monitored area of the wafer, 11, which monitored area is optionally a patternless area such as a clear area or die or which is optionally an area having a pattern. The wafer, 11, is held to the chuck by a mounting pad or "fixture" which is generally attached to the chuck by a chemical adhesive. The fixture is often composed of a base matrix held together by a polyurethane surface layer. The outer surface which holds and presses against the back of the wafer, grips the wafer, and also provides uniform support for the wafer.

In the other embodiment shown in Fig. 4, the rotating table base, 10, and platen, 9, which holds the polishing pad is shown integrated with a rotating coupler, 5′, for a front side approach to the wafer. The bifurcated fiber-optic cable, 4′, is fed into the rotating table base, 10, and connected to the stationary portion of the rotating coupler, 5′. The rotating fiber-optic cable, 6′, connected to the rotating shaft of the rotating coupler, 5′, is adjacent to the monitoring area of the wafer. As the polishing pad attached to the platen, 9, is generally perforated, the end of the fiber-optic cable, 6′, can be embedded in one of the holes. Translucent slurry solution flows in between the polishing pad and the wafer, scattering most visible light wavelengths. Optionally, signal enhancement means can be used to compensate for slurry scattering effects of different light wavelengths. In the preferred embodiment, the source light for the front side method is 632.8 nanometer wavelength light, a wavelength balancing the concerns of light signal transmission

through the slurry, and also accuracy of measurement. The rotating fiber-optic cable, 6′, embedded in the polishing pad must transmit and receive the interference signal when it is positioned over the measurement area on the wafer, 11. This is coordinated so that the monitoring optics pass over the monitored area on the wafer using ordinary skill in the art.

Fig. 5 illustrates the use of an electrical slip ring assembly. A light source, 14, transmits light to a point on the wafer, 11, which causes the light to reflect in the direction of the photodetector or other light-monitoring electronics, 13, which convert the light signal into an electrical signal. The electrical signal may then be passed on to an analyzer, 12, and finally, to an electrical slip ring, 15, where it is decoupled from rotation and passed on to other analyzers which monitor the progress of CMP.

Fig. 6 illustrates a wafer-holding chuck and spindle, 12, wherein the rotating fiber-optic cable, 6, has been routed from the coupler, 5, through the wafer-holding chuck, 12, to a point behind the wafer, 11, during the CMP process. If the pad or "fixture" which holds the wafer does not allow the passage of light, then it can be perforated to provide an optical access to the wafer. In order to compensate for the loss of pressure against the wafer at the point of optical access, air may optionally be pumped into the cavity to press against the wafer and compensate for the loss of pressure. Alternatively, if the fixture is able to transmit light, then the perforation for

optical access is not necessary.

While the invention has been described in detail and with reference to specific embodiments thereof, it will be apparent to one skilled in the art that various changes and modifications can be made therein without departing from the spirit and scope of the invention.

Atty. Doc. No. 50169/110

What is claimed is:

1. A chemical mechanical polisher for planarizing a film on one side of a substrate having two sides comprising at least one light source that transmits light through the substrate from the side of the substrate without the film to at least one section on the film, thereby creating at least one reflected light signal that is received by at least one means for monitoring thickness change based on the reflected light signal.

2. The polisher as claimed in claim 1 wherein said at least one means for monitoring thickness change based on the reflected light signal comprises a photodetector connected to an interferometer or a spectrophotometer.

3. The polisher as claimed in claim 1 wherein each monitored section is minimized in size to remove signal problems.

4. The polisher as claimed in claim 1, wherein only one section is illuminated which is a dedicated measurement area.

5. The polisher as claimed in claim 1, wherein more than one section is illuminated.

6. A chemical mechanical polisher for planarizing a film on one side of a substrate having two sides comprising at least one

light source that transmits light through the substrate from the side of the substrate without the film to at least one section on the film creating at least one reflected light signal that is received by at least one device that monitors a dimensional change based on the reflected light signal.

7. The polisher as claimed in claim 6 wherein the at least one device is positioned on the same side of the substrate as the light source.

8. The polisher as claimed in claim 6 wherein each monitored section is minimized in size to remove signal problems.

9. The polisher as claimed in claim 6, wherein only one section is illuminated which is a dedicated measurement area.

10. The polisher as claimed in claim 6, wherein more than one section is illuminated.

11. A chemical mechanical polisher for planarizing a film on one side of a substrate having two sides comprising at least one light source that transmits light through the substrate from the side of the substrate with the film to at least one section on the film creating at least one reflected light signal that is received by at least one device that monitors a dimensional change based on the reflected light signal.

12. The polisher as claimed in claim 11 wherein the at least one device is positioned on the same side of the substrate as the light source.

13. The polisher as claimed in claim 11 wherein each monitored section is minimized in size to remove signal problems.

14. The polisher as claimed in claim 11, wherein only one section is illuminated which is a dedicated measurement area.

15. The polisher as claimed in claim 11, wherein more than one section is illuminated.

16. A chemical mechanical polisher for planarizing a film on one side of a substrate having two sides comprising at least one light source that transmits light through the substrate from the side of the substrate with the film to at least one section on the film creating at least one reflected light signal that is received by at least one means for monitoring thickness change based on the reflected light signal.

17. The polisher as claimed in claim 16 wherein the at least one means for monitoring thickness change based on the reflected light signal comprises a photodetector connected to an interferometer or spectrophotometer.

18. The polisher as claimed in claim 16 wherein each monitored section is minimized in size to remove signal problems.

19. The polisher as claimed in claim 16, wherein only one section is illuminated which is a dedicated measurement area.

20. An in-situ chemical-mechanical polishing process monitor apparatus for monitoring a polishing process during polishing of a workpiece in a polishing machine, the polishing machine having a rotatable polishing table provided with a polishing slurry, said apparatus comprising:

a) a window embedded within the polishing table, said window traversing a viewing path during polishing and further enabling in-situ viewing of a polishing surface of the workpiece from an underside of the polishing table during polishing as said window traverses a detection region along the viewing path; and

b) means coupled to said window on the underside of the polishing table for measuring a reflectance, said reflectance measurement means providing a reflectance signal representative of an in-situ reflectance, wherein a prescribed change in the in-situ reflectance corresponds to a prescribed

condition of the polishing process.

21. The apparatus of claim 20, wherein: said window further being embedded within the table wherein a top surface of said window is substantially flush with a top surface of the table.

22. The apparatus of claim 20, further comprising: c) means responsive to reflectance signal for detecting the prescribed change in the in-situ reflectance in real-time, said detection means providing an output signal indicative of the detection of the prescribed change in the in-situ reflectance.

23. The apparatus of claim 22, wherein: said window further being embedded within the table wherein a top surface of said window is substantially flush with a top surface of the table.

24. A polishing machine having in-situ polishing process monitor control of a polishing process during polishing of a workpiece on a rotatable polishing table provided with a polishing slurry, said polishing machine comprising:

a) a window embedded within the polishing table, said window traversing a viewing path during polishing and further enabling in-situ viewing of a polishing surface of the workpiece from an underside of the polishing

table during polishing as said window traverses a detection region along the viewing path;

b) means coupled to said window on the underside of the polishing table for measuring a reflectance, said reflectance measurement means providing a reflectance signal representative of an in-situ reflectance, wherein a prescribed change in the in-situ reflectance corresponds to a prescribed condition of the polishing process.

25. The polishing machine of claim 24, wherein: said window further being embedded within the table wherein a top surface of said window is substantially flush with a top surface of the table.

26. The polishing machine of claim 24, further comprising: c) means responsive to the reflectance signal for detecting the prescribed change in the in-situ reflectance in real-time, said detection means providing an output signal representative of the detection of the prescribed change in the in-situ reflectance.

27. The polishing machine of claim 26, further wherein: said window further being embedded within the table wherein a top surface of said window is substantially flush with a top surface of the table.

28. The polishing machine of claim 26, further wherein: said detection means further comprises means responsive to the output signal for controlling the polishing process.

29. The polishing machine of claim 28, still further wherein:

said window further being embedded within the table wherein a top surface of said window is substantially flush with a top surface of the table.

30. The polishing machine of claim 28, still further wherein:

said detection means detects a polishing endpoint corresponding to the prescribed change in the in-situ reflectance, and further wherein said detection means controls the polishing process for terminating the polishing of the workpiece in response to the detection of the polishing endpoint.

31. The polishing machine of claim 28, still further wherein:

said detection means detects a polishing non-uniformity corresponding to the prescribed change in the in-situ reflectance, and further wherein said detection means controls the polishing process for terminating the polishing of the workpiece in response to the detection of the polishing non-uniformity.

Atty. Doc. No. 50169/110

ABSTRACT

A technique and apparatus is disclosed for the optical monitoring and measurement of a thin film (or small region on a surface) undergoing thickness or other changes while it is rotating. An optical signal is routed from the monitored area through the axis of rotation and decoupled from the monitored rotating area. The signal can then be analyzed to determine an endpoint to the planarization process. The invention utilizes interferometric and spectrophotometric optical measurement techniques for the in situ, real-time endpoint control of chemical-mechanical polishing planarization in the fabrication of semiconductor or various electrical devices.

Figure 1.

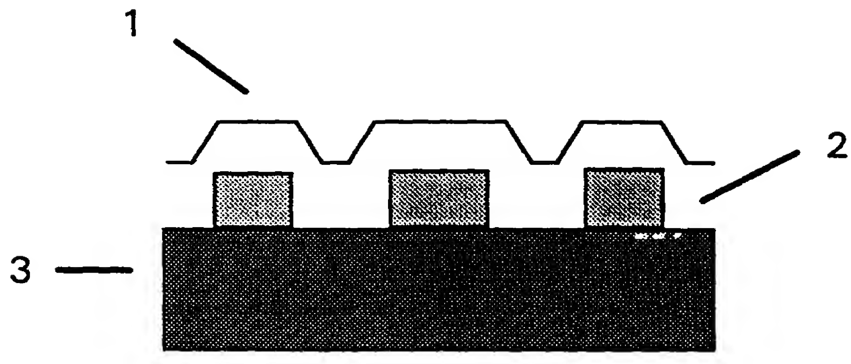


Figure 2.

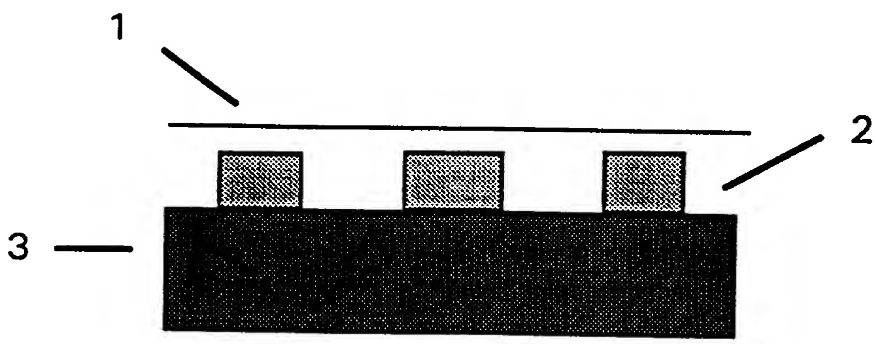


Figure 3.

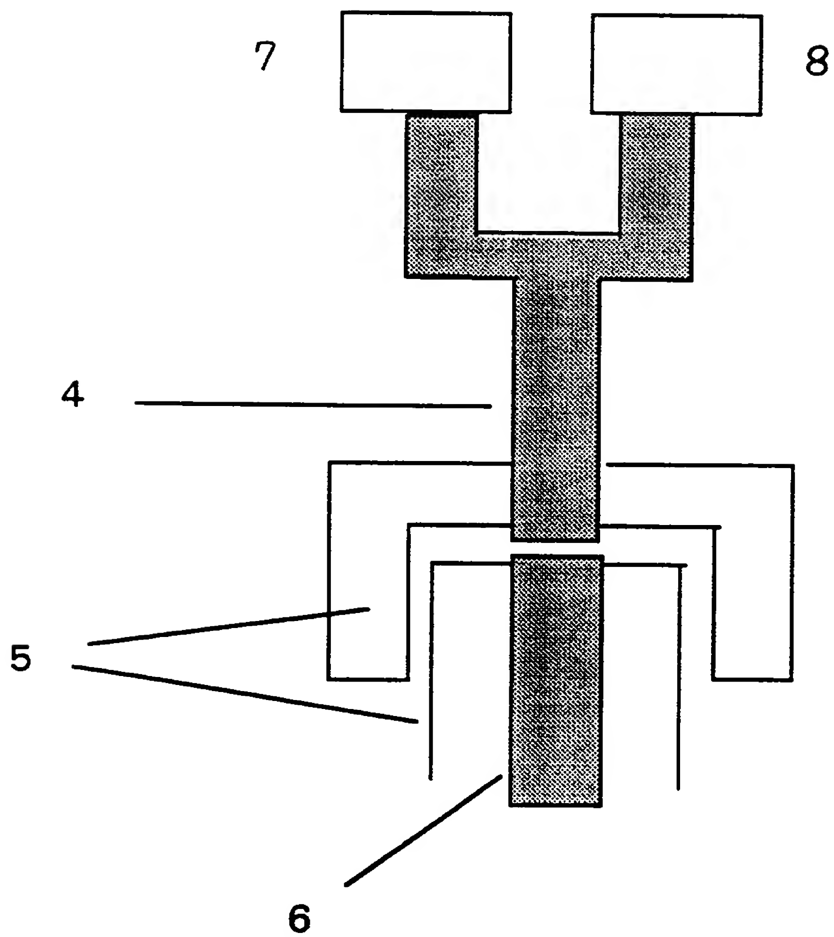


Figure 4.

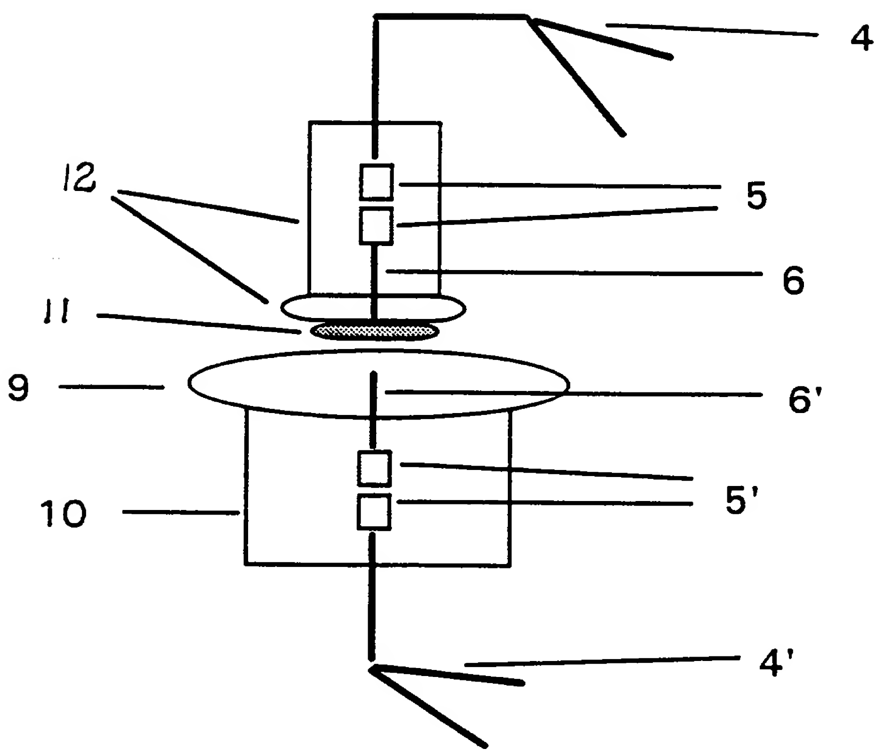


Figure 5.

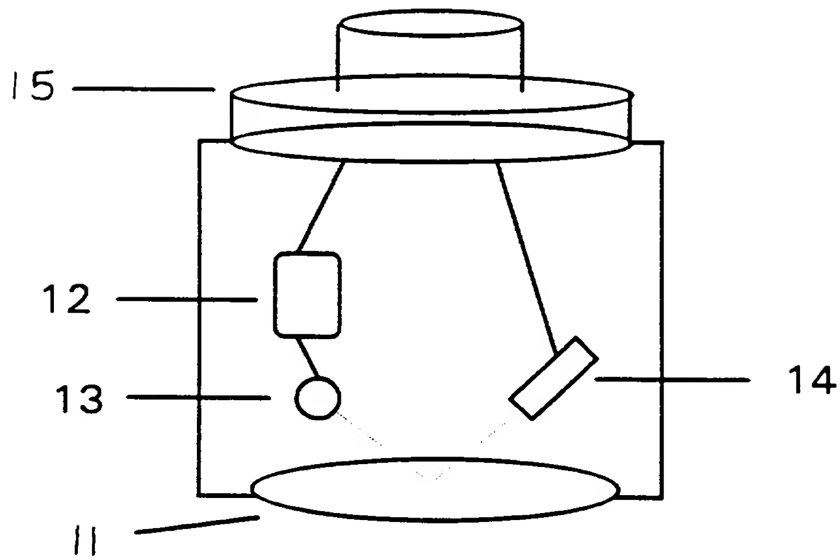
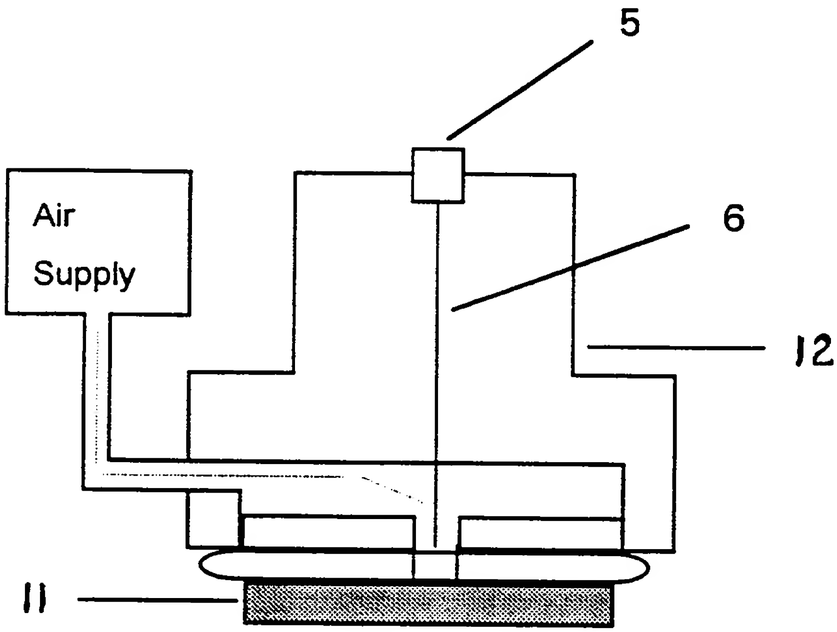


Figure 6.



SMALL ENTITY DECLARATION

☒ APPLICANT OR PATENTEE Wallace T. -Y. TANG

☒ SERIAL NO. 07/996,817 ☐ PATENT NO. ATTORNEY'S DOCKET NO. P2921-23619

☒ FILED OR ISSUED December 28, 1992 ☐ SUBMITTED HEREWITH

FOR IN-SITU REAL-TIME MONITORING TECHNIQUE AND APPARATUS FOR ENDPOINT DETECTION OF THIN FILMS DURING CHEMICAL/MECHANICAL POLISHING PLANARIZA'

I(we) hereby declare that I(we) am(are) entitled to the benefit of small entity status with respect to the above-identified application or patent for purposes of paying reduced fees under 35 USC 41(a) & (b) to the U.S. Patent and Trademark Office.

☒ A. INDEPENDENT INVENTOR
I(we) qualify as a(n) independent inventor(s) as defined in 37 CFR 1.9(c).

☐ B. INDIVIDUAL NON-INVENTOR
I would qualify as an independent inventor as defined in 37 CFR 1.9(c) if I had made the invention.

☐ C. SMALL BUSINESS CONCERN
I am ☐ THE OWNER ☐ AN OFFICIAL of the small business concern identified below and am empowered to act on behalf of the concern. The concern qualifies under 37 CFR 1.9(d) and 13 CFR 121.3-18. Rights under contract or law have been conveyed to and remain with the concern and are exclusive unless a checkmark is placed here ☐ and another Declaration on behalf of another entity is filed herewith.

☐ NON-PROFIT ORGANIZATION
I am an official empowered to act on behalf of the non-profit organization identified below. The organization qualifies under 37 CFR 1.9(e), sub-section: ☐ (1) ☐ (2) ☐ (3) ☐ (4). Rights under contract or law have been conveyed to and remain with the organization and are exclusive unless a checkmark is placed here ☐ and another Declaration on behalf of another entity is filed herewith.

I(we) acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b)).

I(we) hereby declare that all statements made herein of my(our) own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

Name of Inventor	Signature	Date
Wallace T.-Y. Tang	[signature]	2/23/93

Name of Concern or Organization:

Address: 5 Deerwood Trail, Box: 4408 Warren, NJ 07059

By Wallace T.-Y. Tang (Name of Person Signing) — Signature: [signature]

Title: -

Date: 2/23/93

UTILITY PATENT
OR DESIGN
SOLE OR JOINT

WEGNER, CANTOR, MUELLER & PLAYER

UNITED STATES LETTERS PATENT
DECLARATION AND POWER OF ATTORNEY

ATTORNEY'S DOCKET NO
P-2921-23619

As a below named inventor, I declare that I believe I am the original, first and sole inventor if only one name is listed at item 201 below, or a joint inventor if plural names are listed below at items 201 et. seq. of subject matter which is claimed and for which a patent is sought for

the invention entitled: IN-SITU REAL-TIME MONITORING TECHNIQUE AND APPARATUS FOR ENDPOI DETECTION OF THIN FILMS DURING CHEMICAL/MECHANICAL ... which is described and claimed in:

101 ☐ the attached specification ☒ the specification in application Serial No. 07/996,817 filed December 28, 1992
(for declaration not accompanying application papers)
and (if applicable) amended on ...

102 ☐ international (PCT) application No. ... filed ... and as amended on ... (if any)

I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I hereby claim the benefit of priority, under Title 35, United States Code, §119, of any foreign application(s) for patent or inventors certificate having a filing date before that of the application for which priority is claimed.

I hereby claim the benefit, under Title 35, United States Code, §120, of any U.S. application(s) listed in item 105 below. If this application is a continuation-in-part, insofar as the subject matter of any of the claims thereof is not disclosed in the prior U.S. application(s) identified in item 105 below in the manner provided by the first paragraph of Title 35, United States Code, §112. I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior U.S. application(s) identified in item 105 below and the national or PCT international filing date of this application.

103 FOREIGN APPLICATION(S), IF ANY, FILED WITHIN 12 (6 if a Design) MONTHS PRIOR TO THE FILING DATE OF THIS APPLICATION THE PRIORITY OF WHICH WHERE PERMITTED IS HEREBY CLAIMED UNDER 35 U.S.C. §119

COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED YES	NO

106	THIS APPLICATION IS A: ☐ CONTINUATION ☐ DIVISION ☐ CONTINUATION-IN-PART OF PRIOR U.S. APPLICATION	SERIAL NO.	FILED

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

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	RESIDENCE CITIZENSHIP	CITY OR OTHER LOCATION	STATE OR COUNTRY	CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS		

☐ Fourth (and more) coinventors on page 2

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
DATE 2/23/93	DATE	DATE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Attorney Docket No.: 50169/102/ENPO

In re patent application of

Wallace T.Y. TANG

Serial No.: 07/996,817 Group Art Unit: 2607

Filed: December 28, 1992 Examiner: H. Pham

For: IN-SITU REAL-TIME MONITORING TECHNIQUE AND APPARATUS FOR ENDPOINT DETECTION OF THIN FILMS DURING CHEMICAL/MECHANICAL POLISHING PLANARIZATION

ASSOCIATE POWER OF ATTORNEY

The Honorable Commissioner of
Patents and Trademarks
Washington, D.C. 20231

Sir:

The undersigned attorney of record hereby grants the following attorney(s)/agent(s) an associate power to prosecute the above-identified application and transact all business in the Patent and Trademark Office connected therewith:

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Respectfully submitted,

November 23, 1994
Date

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